advancing seasons, but seem to be true oscillations whose corresponding phases occur at the same time each year. A complete explanation of this phenomenon will doubtless await a long and detailed analysis of the complex changes in the distribution of temperature and pressure over the globe resulting from seasonal changes and from changes in solar radiation.

551.578.1 : 623.421

RAINFALL AND GUNFIRE.[1]

By ALFRED ANGOT, Director,
Bureau Central Météorologique de France.

[*Review reprinted from* Nature, London, Aug. 9, 1917, 99:467-8.]

M. Angot, the eminent director of the French Meteorological Service, has made a valuable and authoritative contribution, published in the journal of the French Academy of Agriculture for May, to the literature of a well-worn controversy.[1] The alleged connection between rainfall and gunfire, in favor of which so many champions sprang up during the wet periods of 1914–1916, has recently lost favor as a subject for argument, owing, no doubt, to the coincidence of the Spring drought of 1917 with the Allied offensive on the western front; but so short is the public memory, especially for negative evidence, that the incidence of 3 inches of rain during a recent summer afternoon in London, N. W., has proved sufficient to disinter the bone of contention [below p. 453]. The mental attitude of the public toward a theory of this nature is of great psychological interest: there is little doubt that, should we experience this summer [1917] a repetition of the weather of July, 1888, when snow fell in London, followed by a recurrence of that of August, 1911, when the thermometer touched 100°F. at Greenwich, both phenomena would generally be attributed to the war.

Accordingly M. Angot's paper reaches us at an opportune moment. After dealing briefly with the historical aspect of the question, and alluding to the work of M. Le Maout—who, not content with having established a connection between the bombardments of the Crimean War and the rainfall of India, the United States, Nicaragua, and Barbados, went on to ascribe the diurnal variation of the barometer to the striking of public clocks and the ringing of church bells—M. Angot proceeds to consider the physical changes which could be effected by the discharge of artillery, and could at the same time be held responsible for the causation, increase, or acceleration of rainfall.

The first proposition is that a succession of violent explosions might result in the displacement of masses of cold air at certain heights, which, coming under the influence of the upper winds and encountering layers of warmer, saturated air, could give rise to precipitation which would not otherwise have occurred: in this connection the author points out that in order to obtain a rainfall of so small an order as 1 mm. (0.04 in.), even if one were to take two equal masses of saturated air, the one at a temperature of 0° C., the other at 20° C. (an extreme case, of course), it would be necessary to effect a rapid and thorough intermingling of the two throughout a layer of air 6,850 meters in thickness. In M. Angot's opinion, the mixing of layers of air may be the cause of cloud formation or of slight drizzle at the earth's surface, but can never be responsible for considerable precipitation.

In the case of the second proposition—that water vapor resulting from chemical reaction of the explosives might take effect—it is asserted that in order to produce the same amount of rainfall (1 mm.) as in the previous proposition, the employment of no fewer than 21,750 tons of melinite per square mile would be necessitated—that, indeed, only on the supposition that all the hydrogen in the explosive became water vapor, which condensed immediately in its entirety and, so to speak, on the spot.

In the third and last instance, the possibility of electrical action being brought into play is considered in some detail. We know that supersaturated air (i. e., air which contains more water vapor than it normally should be able to hold for the existing temperature) is a physical possibility, in the absence of dust particles or other matter which may form nuclei for condensation. The necessary medium may be supplied by the action of ozone, of ultraviolet rays, by any cause, in fact, which can set up ionization of the atmosphere; under this last category may be classed the detonation of high explosives, inasmuch as highly ionized gases result therefrom. The lower regions of the atmosphere, however, which alone are the seat of explosive activity on a large scale, always harbor large numbers of both ions and dust particles, and can not, therefore, be subject to supersaturation; while it has yet to be shown that the addition of quantities of ions or of dust particles to a stratum of atmosphere nearly, but not quite, saturated can bring about premature condensation. Assuming for the moment the possibility of such a hypothesis, we must consider that no outpouring of ions or dust particles can do more than accelerate a precipitation which would be necessitated sooner or later by the progressive cooling of the air, since the mass of water that results from the cooling of, say, a kilogram of saturated air from 15° C. to 0° C. is constant (rather more than 5 grams), whether or not supersaturation may have existed at the inception of the temperature reduction.

Having thus pronounced upon the theories which have been advanced to account for the alleged connection, M. Angot goes on to consider whether in reality anything has occurred that needs accounting for—whether the rainfall since the outbreak of hostilities has been less inclined to observe the rules by which we endeavor to forecast its occurrence than before. Careful comparison between the daily weather maps and the observed rainfall figures has convinced him that it is not. He points out, very rightly, that we have been passing through a series of wet years since 1909—a period that balances the run of dry years 1898–1904 (1903 and 1911 were both exceptions to their groups and may be said to balance each other)—and that excess of rain in 1915 and 1916 might reasonably have been expected; that 1909 was wetter (in France) than 1915; 1910 than 1916; furthermore, that during December, 1915, an unprecedentedly wet month, relative calm prevailed over the whole front, and that in the second 10-day period of the very wet February of 1916, considerably more rain fell (40 mm. as against 28 mm.) than in the last 10-day period, which witnessed the development of the giant German bid for Verdun. Similar conclusions will be reached if frequency of rain instead of amount be considered: 1910 had more rain-days than 1916; 1912 and 1913 both had more than 1915, when the number in France was 11 below the average. The author has found nothing exceptional in the local distribution of rainfall: proximity to the firing zone has not resulted in relatively greater

[1] *Angot, Alfred.* Le canon et la pluie. Comptes rendus, Acad. d'agric. (France), No. 18, 1917, 3: 501–508.

totals or frequencies, while the great Spring offensive of 1917 failed to interrupt the long spell of brilliant weather which accompanied it.

An examination was made some months ago at the British Meteorological Office into the local distribution of rainfall over England during the first 22 months of the war, the results of which afford corroborative evidence for M. Angot's last-mentioned point. It was found that the greatest excess of rain over the normal figure was one of 59 per cent on the south Yorkshire coast; that three areas in Lincolnshire and on the Norfolk and Suffolk coasts, respectively, had rather more than 40 per cent excess; but that round the North Foreland there was a slight deficit. No trace whatever of a distribution having reference to a center over northern France was discoverable.

M. Angot concludes with the reflection that it may be with rainfall and gunfire as it is with weather changes and the phases of the moon, that—

sous la suggestion d'une croyance instinctive on est conduit involontairement à ne remarquer que les coïncidences favorables et à s'affermir ainsi de plus en plus dans cette croyance.

[under the suggestion of an instinctive belief, one is involuntarily led to note only the favorable coincidences and thus become more and more confirmed in the belief.]

For those, indeed, who are cognizant of the relationship between the weather and modern warfare it is not difficult to see the possibility of the connection, but it is a connection in which the amount of gun fire varies inversely as the amount of rain that is falling rather than one which makes the rainfall in any way dependent on the gunfire.—*E. L. Hawke.*

551.5 : 591.5 (494)

BIRD MIGRATION IN CENTRAL SWITZERLAND IN RELATION TO METEOROLOGICAL CONDITIONS.[1]

By Dr. K. BRETSCHER.

[*Reprinted from* Nature, London, Sept. 20, 1917, 100:47—48.]

The relation of bird migration to meteorological conditions has been considered, of late years, an important part of the study of the movements of birds, and various theories have been advanced to explain their interrelations. In the memoir before us Dr. Bretscher deals very fully with the arrival in Spring and departure in Autumn of the summer visitors to central Switzerland. In relation to these he treats of bird migration and atmospheric pressure, wind, atmospheric precipitation, temperature, etc., and under each heading he has tables of statistics in support of the statements in the text. By Tables 1 and 15 he shows that the position of barometric depressions within the area has, as we should expect, no influence on the arrival of the summer migrants and their departure in autumn. In Tables 3 and 4 he discusses the influence of direction and strength of the wind, and concludes that, in central Switzerland, migration proceeds irrespective of the direction of the wind and that, unless the force be so great as to be a hindrance, the influence of this, too, may be regarded as a negligible quantity. The fourth section deals with atmospheric precipitation in relation to bird migration; as the author tells us in Switzerland even keen ornithologists stay at home in wet weather, we are not surprised to find that they have few direct records of migration in rain, snow, or fog, and he himself says, further observations on th subject are wanted.

What strikes one as being the most interesting of any of the sections are those on spring and autumn migration in relation to temperature. Dr. Bretscher gives many interesting tables showing the number of observations on the movements of each species under each degree of temperature centigrade. These indicate the maximum and minimum between which migration takes place, the gradual increase to the most favorable migration temperature, and the decrease after this is reached. Here we see that birds migrate between certain temperatures, which vary according to the species; thus, the blackbird and song thrush perform their migrations at a lower temperature than the insect-eating warblers. Another aspect is presented in Table 9—namely, the duration of the migration period in relation to the average temperature—and the author here comes to the conclusion that the two are not correlated; thus the warmest average temperature does not necessarily coincide with the shortest migration period, nor does a cold spell mean a lengthening of the time over which the migration extends. Table 10 shows the difference of temperature of the migration day and that directly preceding it, and purports to prove that it is the temperature of the moment, not that which went before, which incites birds to migrate. It seems, however, as if the author had somewhat confused the issue; it can not be the temperature at the point of arrival which incites the birds to begin its migration in Spring. After this we have the various migration dates compared for Switzerland, Hungary, Bavaria, and Württemberg, though as the last has only three entries we think it might have been omitted.

In conclusion, the author indicates his conviction, which is probably shared by most ornithologists, that the real incentive to migration is not to be found in outward circumstances, but must be sought in physiological conditions. The outward conditions, including food, do undoubtedly have some effect on it, but do not produce the necessary impulse. Though there is perhaps nothing startlingly new in this pamphlet, yet it is a welcome addition to the literature relating to migration; it shows much careful work, and the fact that Dr. Bretscher refrains from drawing more than very tentative conclusions adds to, rather than detracts from, its value. He realizes that it is not possible to come to any definite solution of the problem he is studying without observations—and we would add, meteorological data—made over a much wider field.—*W. E. C.*

Weather Bureau men may recall an interesting illustrated article on bird migrations across North and South America, published in the National Geographic Magazine, April, 1911, by W. W. Cooke. One of Mr. Cooke's maps of dates of arrival in the United States is very strongly suggestive of a map of isotherms for the region. In a note accompanying a report of the effect of a severe storm in 1899 on bird movements, Professor Abbe [2] also pointed out that bird movements were chiefly controlled by food supply; but food supply is controlled by the weather and the climate and no doubt some of our experts in correlation investigations will be able to show a close correlation between bird movements and some one of our weather factors. Perhaps such a study has already been made.—C. A., jr.

[1] "Der Vogelzug im schweizerischen Mittelland in seinem Zusammenhang mit den Witterungsverhältnissen." Von Dr. K. Bretscher. Nouveaux mémoires de la Société Helvétique des Sciences naturelles, vol. 51, mem. 2.

[2] *See* MONTHLY WEATHER REVIEW, February, 1899, 27:60.